CLAIMS

What is claimed is:

1. A light-emitting diode comprising:

a substrate;

a light-emitting structure disposed above the substrate along a vertical axis, the light-emitting structure including a first cladding layer and a second cladding layer;

a first electrode in contact with the first cladding layer of the light-emitting structure, the first electrode having a leg extending in a first direction along a horizontal axis perpendicular to the vertical axis; and

a second electrode in contact with the second cladding layer of the light-emitting structure, the second electrode having at least two legs extending in a second direction opposite the first direction along the horizontal axis, a portion of the leg of the first electrode disposed between and spaced apart from respective portions of the two legs of the second electrode.

2. The light-emitting diode of claim 1 further comprising a thin metal layer disposed above the light-emitting structure along the vertical axis and in contact with the light-emitting structure, the first electrode extending through the thin metal layer along the vertical axis to contact the first cladding layer, the first electrode defining a first elevation along the vertical axis.

3. The light-emitting diode of claim 2, wherein the second electrode is in contact with a surface of the second cladding layer in a well formed to expose the surface, the second electrode defining a second elevation lower than the first elevation along the vertical axis.

4. The light-emitting diode of claim 1, wherein the first cladding layer is a P cladding layer and the second cladding layer is an N cladding layer, and the first electrode is a P electrode and the second electrode is an N electrode.

5. The light-emitting diode of claim 1, wherein the first cladding layer is an N cladding layer and the second cladding layer is a P cladding layer, and the first electrode is an N electrode and the second electrode is a P electrode.

6. The light-emitting diode of claim 1, wherein the portion of the leg of the first electrode is spaced apart from one of the portions of the two legs of the second electrode in substantially equal distance along the portion of the leg of the first electrode and the portion of the leg of the second electrode.

7. The light-emitting diode of claim 1, wherein the portions of the legs of the first and second electrodes are substantially straight.

8. The light-emitting diode of claim 1, wherein the portion of the leg of the first electrode is straight and the portions of the legs of the second electrode are curved.

9. The light-emitting diode of claim 1, wherein the portion of the leg of the first electrode is straight and the portions of the legs of the second electrode are angled.

10. The light-emitting diode of claim 1, wherein the second electrode includes a straight arm that branches into curved segments, the curved segments including the portions of the two legs of the second electrode.

11. The light-emitting diode of claim 1, wherein the second electrode includes a straight arm that branches into angled segments, the angled segments including the portions of the two legs of the second electrode.

12. The light-emitting diode of claim 1, wherein the leg of the first electrode is tapered in the first direction.

13. The light-emitting diode of claim 1, wherein the portions of the legs of the second electrode are tapered in the second direction.

14. The light-emitting diode of claim 1, wherein the leg of the first electrode has an enlarged portion at an end of the leg.

15. The light-emitting diode of claim 14, wherein the enlarged portion has a circular shape.

16. The light-emitting diode of claim 14, wherein the enlarged portion has a square shape.

17. The light-emitting diode of claim 14, wherein the leg of the first electrode further comprises an extension from the enlarged portion.

18. The light-emitting diode of claim 1, wherein the legs of the second electrode have enlarged portions at respective ends of the legs.

19. The light-emitting diode of claim 18, wherein the enlarged portions have circular shapes.

20. The light-emitting diode of claim 18, wherein the legs of the second electrode further comprise respective extensions from the enlarged portions.

21. The light-emitting diode of claim 1, wherein the first electrode includes two additional outer legs extending in the first direction, the two legs of the second electrode disposed between the two outer legs of the first electrode.

22. The light-emitting diode of claim 21, wherein the two outer legs are substantially straight.

23. The light-emitting diode of claim 22, wherein the two outer legs each have respective enlarged portions along the leg.

24. The light-emitting diode of claim 23, wherein the enlarged portions have semicircular shapes.

25. The light-emitting diode of claim 21, wherein the two outer legs are curved.

26. The light-emitting diode of claim 21, wherein the two outer legs are angled.

27. The light-emitting diode of claim 21, wherein the two outer legs are tapered in the first direction.

28. The light-emitting diode of claim 1, further comprises a reflective layer disposed below the substrate and in connection with the bottom side of the substrate.

29. The light-emitting diode of claim 1, wherein the leg of the first electrode and the legs of the second electrode define a region capable of passing light.

30. The light-emitting diode of claim 29, wherein the region is substantially in a M shape.

31. The light-emitting diode of claim 29, wherein the region has a plurality of channels disposed therein, the channels further dividing the region into sub-regions.

32. The light-emitting diode of claim 31, wherein the sub-regions are substantially in rectangular shapes.

33. The light-emitting diode of claim 31, wherein at least one of the channels has a vertical wall.

34. The light-emitting diode of claim 31, wherein at least one of the channels has an angled wall.

35. A light-emitting diode comprising:

a substrate;

a reflective layer disposed below the substrate and in connection with the bottom side of the substrate;

a light-emitting structure disposed above the substrate along a vertical axis, the light-emitting structure including a first cladding layer and a second cladding layer;

a thin metal layer disposed above the light-emitting structure along the vertical axis and in contact with the light-emitting structure;

a first electrode disposed above the light-emitting structure along the vertical axis, extending through the

thin metal layer along the vertical axis, and in contact with the first cladding layer of the light-emitting structure, the first electrode having a plurality of legs extending in a first direction along a horizontal axis perpendicular to the vertical axis, the legs being tapered in the first direction; and

a second electrode disposed above an exposed surface of the second cladding layer along the vertical axis and in contact with the exposed surface, the second electrode having a plurality of legs extending in a second direction opposite the first direction along the horizontal axis, the legs of the second electrode being tapered in the second direction, the legs of the first electrode interspersed with and spaced apart from the legs of the second electrode.

36. The light-emitting diode of claim 35, wherein the first cladding layer is a P cladding layer and the second cladding layer is an N cladding layer, and the first electrode is a P electrode and the second electrode is an N electrode.

37. The light-emitting diode of claim 35, wherein the first cladding layer is an N cladding layer and the second cladding layer is a P cladding layer, and the first electrode is an N electrode and the second electrode is a P electrode.

38. The light-emitting diode of claim 35, wherein the first electrode defines a first elevation, and the second electrode is disposed in a well, the second electrode defining a second elevation lower than the first elevation along the vertical axis.

39. The light-emitting diode of claim 35, wherein the legs of the first and second electrodes are straight.

40. The light-emitting diode of claim 35, wherein the legs of the first electrode have enlarged portions at respective ends of the legs.

41. The light-emitting diode of claim 40, wherein the enlarged portions have substantially circular shapes.

42. The light-emitting diode of claim 40, wherein at least one of the legs of the first electrode further comprises a minor extension extending from the enlarged portion.

43. The light-emitting diode of claim 35, wherein the legs of the second electrode have enlarged portions at respective ends of the legs.

44. The light-emitting diode of claim 43, wherein the enlarged portions have substantially circular shapes.

45. The light-emitting diode of claim 43, wherein at least one of the legs of the second electrode further comprises a minor extension extending from the enlarged portion.

46. The light-emitting diode of claim 35, wherein the legs of the first electrode and the legs of the second electrode define a surface region capable of passing light.

47. The light-emitting diode of claim 46, wherein the surface region has a M shape.

48. The light-emitting diode of claim 46, wherein the region has a plurality of channels disposed therein, the channels further dividing the region into sub-regions.

49. A light-emitting diode comprising:

a substrate;

a light-emitting structure disposed above the substrate along a vertical axis, the light-emitting structure including a first cladding layer and a second cladding layer;

a thin metal layer disposed above the light-emitting structure along the vertical axis and in contact with the light-emitting structure;

a first electrode disposed above the light-emitting structure along the vertical axis, extending through the thin metal layer along the vertical axis, and in contact with the first cladding layer of the light-emitting structure, the first electrode having a plurality of legs extending in a first direction along a horizontal axis

perpendicular to the vertical axis, at least one leg having an enlarged portion at its end; and

a second electrode disposed above an exposed surface of the second cladding layer along the vertical axis and in contact with the exposed surface, the second electrode having a plurality of legs extending in a second direction opposite the first direction along the horizontal axis, the legs of the first electrode interspersed with and spaced apart from the legs of the second electrode to define a region capable of passing light.

50. The light-emitting diode of claim 49, wherein the first cladding layer is a P cladding layer and the second cladding layer is an N cladding layer, and the first electrode is a P electrode and the second electrode is an N electrode.

51. The light-emitting diode of claim 49, wherein the first cladding layer is an N cladding layer and the second cladding layer is a P cladding layer, and the

first electrode is an N electrode and the second electrode is a P electrode.

52. The light-emitting diode of claim 49, wherein each of the legs of the first electrode is spaced apart from a respective neighboring leg of the second electrode in substantially equal distance along the horizontal axis.

53. The light-emitting diode of claim 49, wherein at least one of the legs of the first electrode is tapered in the first direction.

54. The light-emitting diode of claim 49, wherein at least one of the legs of the second electrode is tapered in the second direction.

55. The light-emitting diode of claim 49, wherein the enlarged portion has a substantially circular shape.

56. The light-emitting diode of claim 49, wherein the enlarged portion has a minor extension extending therefrom.

57. A light-emitting diode comprising:

a substrate;

a reflective layer disposed below the substrate and in connection with the bottom side of the substrate;

a light-emitting structure disposed above the substrate along a vertical axis, the light-emitting structure including a P cladding layer and an N cladding layer, the P cladding layer disposed above the N cladding layer along the vertical axis;

a thin metal layer disposed above the P cladding layer of the light-emitting structure along the vertical axis and in contact with the P cladding layer;

a P electrode disposed above the P cladding layer of the light-emitting structure along the vertical axis to define a first elevation, extending through the thin metal layer along the vertical axis, and in contact with the P cladding layer, the P electrode having a plurality of legs extending in a first direction along a horizontal axis perpendicular to the vertical axis, the legs being tapered in the first direction and having enlarged regions at respective ends of the legs; and

an N electrode disposed above the N cladding layer of the light-emitting structure along the vertical axis, the N electrode in contact with a surface of the N cladding layer in a well formed to expose the surface, the N electrode defining a second elevation offset from the first elevation along the vertical axis, the N electrode having a plurality of legs extending in a second direction opposite the first direction along the horizontal axis, the legs of the N electrode being tapered in the second direction and having enlarged regions at respective ends of the legs, the legs of the P electrode interspersed with and spaced apart from the legs of the N electrode.

58. The light-emitting diode of claim 57, wherein the second elevation is lower than the first elevation.

59. The light-emitting diode of claim 57, wherein the legs of the first electrode and the legs of the second electrode define a surface region capable of passing light.

60. The light-emitting diode of claim 59, wherein the surface region is substantially in a M shape.

61. The light-emitting diode of claim 59, wherein the surface region has a plurality of channels disposed therein, the channels further dividing the surface region into sub-regions.

62. The light-emitting diode of claim 61, wherein the sub-regions are substantially in rectangular shapes.

63. A method of making a light-emitting diode, the method comprising:

providing a substrate;

forming a light-emitting structure above the substrate along a vertical axis, the light-emitting structure including a first cladding layer and a second cladding layer;

forming a first electrode above the light-emitting structure along the vertical axis, the first electrode coupled to the first cladding layer of the light-emitting

structure, the first electrode having a leg extending in a first direction along a horizontal axis perpendicular to the vertical axis; and

forming a second electrode on an exposed surface of the second cladding layer, the second electrode having two legs extending in a second direction opposite the first direction along the horizontal axis, wherein a portion of the leg of the first electrode is disposed between and spaced apart from respective portions of the two legs of the second electrode.

64. The method of claim 63, further comprising forming a thin metal layer above the light-emitting structure along the vertical axis and in contact with the light-emitting structure.

65. The method of claim 64, wherein the first electrode extends through the thin metal layer along the vertical axis to define a first elevation, and the second electrode defines a second elevation lower than the first elevation.

66. The method of claim 63, wherein the portion of the leg of the first electrode is straight, and the portions of the two legs of the second electrode are at least one of straight, curved and angled.

67. The method of claim 63, wherein the portion of the leg of the first electrode is tapered in the first direction.

68. The method of claim 63, wherein the portions of the legs of the second electrode are tapered in the second direction.

69. The method of claim 63, wherein the leg of the first electrode has an enlarged portion at end of the leg.

70. The method of claim 63, wherein the legs of the second electrode have enlarged portions at ends of the legs.

71. The method of claim 63, further comprising forming a plurality of channels within a surface region defined by

the leg of the first electrode and the legs of the second electrode, the surface region being divided into sub-regions by the channels.

72. A method of making a light-emitting diode, the method comprising:

providing a substrate;

forming a reflective layer below the substrate;

forming a light-emitting structure above the substrate along a vertical axis, the light-emitting structure including a first cladding layer and a second cladding layer;

forming a thin metal layer above the light-emitting structure along the vertical axis and coupled to the light-emitting structure;

etching the thin metal layer to define a first opening in the thin metal layer exposing a portion of the first cladding layer of the light-emitting structure;

coupling a first electrode to the first cladding layer via the first opening, the first electrode comprising a plurality of legs extending in a first

direction along a horizontal axis perpendicular to the vertical axis;

etching the light-emitting diode to define a second opening exposing a portion of the second cladding layer of the light-emitting structure; and

coupling a second electrode to the second cladding layer via the second opening, the second electrode comprising a plurality of legs extending in a second direction opposite the first direction along the horizontal axis, the legs of the first electrode interspersed with and spaced apart from the legs of the second electrode.

73. The method of claim 72, wherein the first electrode defines a first elevation along the vertical axis, and the second electrode defines a second elevation, the second elevation being lower than the first elevation.

74. The method of claim 72, wherein the legs of the first electrode are at least one of straight, curved and angled, and the legs of the second electrode are at least one of straight, curved and angled.

75. The method of claim 72, wherein the legs of the first electrode are tapered in the first direction.

76. The method of claim 72, wherein the legs of the second electrode are tapered in the second direction.

77. A plurality of light emitting diodes as disclosed in claim 1, wherein each of said plurality of light emitting diodes is positioned in a closed spaced apart relationship to at least one of said plurality of light emitting diodes.

78. A plurality of light emitting diodes as disclosed in claim 35, wherein each of said plurality of light emitting diodes is positioned in a closed spaced apart relationship to at least one of said plurality of light emitting diodes.

79. A plurality of light emitting diodes as disclosed in claim 57, wherein each of said plurality of light emitting diodes is positioned in a closed spaced apart

relationship to at least one of said plurality of light emitting diodes.